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Mechanisms of postural threat: The Achilles heel of postural control?

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Understanding the underlying mechanisms of bipedal stance, or postural control, is critical for fall prevention, especially in older adults and clinical populations. Postural control is an adaptive process that relies on sensory, motor and cognitive processes, and can also be affected by emotional contexts. One such context is fear of falling which has been assessed using a paradigm of standing on the edge of a surface raised approximately 1-3m from the ground (Carpenter et al. 2001). When standing on this surface participants move their centre of gravity away from the edge, and exhibit a stiffening strategy reflected in a reduction in postural sway amplitude, increase in sway frequency and co-contraction of the muscles around the ankle joint. So, we know that this strategy exists, but what do we know about its underlying mechanisms?

The answer is not much until recently, but a number of recent studies assessed whether fear of falling affects sensory sensitivity in vestibular and proprioceptive systems. Early studies showed that in the vestibular system results were unclear. One study showed that fear of falling results in an increase in vestibular system gain using high-frequency vestibular stimulation (Horslen et al. 2014) but another study showed that fear of falling did not result in greater early (feedforward) response to vestibular stimulation and in fact it resulted in a reduced later (feedback) response to this stimulation (Osler et al. 2013). However, a series of later studies provided support for the idea of a vestibular contribution to threat-related changes in postural control (Lim et al. 2017; Naranjo et al. 2016, 2017). On the other hand, evidence in proprioception was more clear-cut, with fear of falling causing an increase in muscle spindle sensitivity (Davis et al. 2011, Horslen et al. 2013). Results from these recent studies suggest that we still know very little about the way sensory systems involved in postural control are

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affected by fear of falling and that we need to identify additional methods to assess the sensory systems involved in this context.

The paper by Horslen et al. (2017) in this issue of the Journal of Physiology contributes to our understanding of these mechanisms. The study utilised a method that has not hitherto been used in the context of postural control to evaluate changes in sensitivity of one of the receptors involved in this task, the Golgi Tendon Organs (GTOs). This study assessed the short-latency GTO – Ib reflex which contributes to balance by evaluating body loading and by the setting of anti-gravity muscle activity, by means of Achilles tendon electrical stimulation. GTO - Ib reflex inhibition has been primarily assessed in seated or lying contexts, however this study extended its assessment to standing and postural threat. Results showed that the level of Ib inhibition was reduced, both by standing compared to lying prone and by postural threat while standing on an elevated surface. The critical aspect of this study is that it provides additional, solid evidence suggesting that postural threat and the resulting stiffening behaviour is linked with changes in the sensory properties of the muscle in humans.

In a broader context, this stiffening strategy, which is geared towards reducing body movement as a result of fear of falling has parallels with the freezing response observed in fear-conditioned animals. One important distinction between the recent paper by Horslen et al. (2017), which mostly focuses on posture-induced threat, and the work on freezing in animals is that in the latter the freezing response is a result of a non-postural threat context. Thus, the stiffening strategy and the observed changes in sensory function in humans may not be unique to postural threat. For instance, evidence suggests that a similar strategy is observed when stress and anxiety is induced by presenting aversive and threatening stimuli to participants (Volchan et al. 2017, Hagenaars et al. 2012) and may be a general, rather than a fear-of-falling specific strategy. Thus, it is possible that context-dependent changes in sensory function, including the reduction in GTO-Ib reflex inhibition identified for the first time by Horslen and colleagues, are caused not only by postural threat and fear of falling but also by other stress- and fear-inducing contexts causing a stiffening postural response.

References

Carpenter MG, Frank, JS, Silcher CP, Peysar GW, (2001). The influence of postural threat on the control of upright stance. *Exp Brain Res* 138**,** 210–218.

Davis JR, Horslen BC, Nishikawa K, Fukushima K, Chua R, Inglis JT & Carpenter MG (2011). Human proprioceptive adaptations during states of height-induced fear and anxiety. *J Neurophysiol* 106, 3082-3090.

Hagenaars, M.A., Stins, J.F., Roelofs, K., (2012). Aversive life events enhance human freezing responses. *J Exp Psychol Gen* 141, 98–105,

Horslen BC, Dakin CJ, Inglis JT, Blouin JS, Carpenter MG. (2014). Modulation of human vestibular reflexes with increased postural threat. *J Physiol, 15,* 3671-3685

Horslen BC, Inglis JT, Blouin JS & Carpenter MG (2017). Both standing and postural threat decrease Achilles tendon reflex inhibition from tendon electrical stimulation. J Physiol, doi: 10.1113/JP273935

Horslen BC, Murnaghan CD, Inglis JT, Chua R & Carpenter MG (2013). Effects of postural threat on spinal stretch reflexes: evidence for increased muscle spindle sensitivity? *J Neurophysiol* 110, 899-906.

Lim SB, Cleworth TW, Horslen BC, Blouin JS, Inglis JT & Carpenter MG (2017). Postural threat influences vestibular-evoked muscular responses. *J Neurophysiol, 117,* 604-611.

Naranjo EN, Allum JH, Inglis JT, Carpenter MG. Increased gain of vestibulospinal potentials evoked in neck and leg muscles when standing under height-induced postural threat. *Neuroscience, 293,* 45-54.

Naranjo EN, Cleworth TW, Allum JH, Inglis JT, Lea J, Westerberg BD & Carpenter MG. (2016). Vestibulo-spinal and vestibulo-ocular reflexes are modulated when standing with increased postural threat. *J Neurophysiol, 115,* 833-842.

Osler CJ, Tersteeg MC, Reynolds RF & Loram ID (2013). Postural threat differentially affects the feedforward and feedback components of the vestibular-evoked balance response. *Eur J Neurosci* 38, 3239-3247.

Volchan, E. et al. Immobility reactions under threat: A contribution to human defensive cascade and PTSD (2017). *Neurosci Biobehav Rev.* doi:10.1016/j.neubiorev.2017.01.025